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ENVIRONMENTAL PHYSICAL QUANTITIES IMPACT ON EMERGENCE OF SICK BUILDING SYNDROME ON USERS OF PUBLIC BUILDINGS IN LAGOS, NIGERIA

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ABSTRACT

The harmful impact of constructed facilities on human wellbeing is serious phenomenon in the built environment. Empirical evidence from literature revealed that sick building syndrome (SBS) is among the significant causes of increased health care cost, loss of employee's productivity and users discomfort. SBS is recognized as a condition in which the building users bear awful health or uneasiness that appear to be accompanying to the time used in the building with no clinical definition or an identifiable cause. This study therefore, focuses on investigating the impact of environmental physical quantities on emergence of SBS symptoms on staff and worshippers in selected public buildings in Lagos, tropical climate. A hybrid research approaches of one-time survey and field measurement was utilized. Descriptive statistics was carried out on the data obtained and are presented on tables and figures. The results signposted that among all the dynamics appraised, higher room temperature (>25^{o}C) relates to the establishment of SBS symptoms among study respondents. The import of this study hinges on offering understanding and cognizance of SBS symptoms to facilities management departments of tertiary and financial institutions in Nigeria. The study also showed the environmental physical quantities ranks that can be relatively felt in public buildings in tropical region of Nigeria.

Keywords: Environmental physical quantities; mold; public buildings; sick building syndrome

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1. INTRODUCTION

There has been increasing concern on challenges associated with buildings that are enveloped sealed. Studies of Wan and Li [1] note that designers incline to attain energy efficient buildings through air-conditioning recirculation systems and close windows method. They further opine that this design approach permits emission of noxious gasses from construction materials to remain longer and in higher dilutions than in lesser air tight buildings. Also, water leakages in buildings create an ideal milieu for development of mold, bacteria and biofilm parasites [2]. Health challenges as a result of time spent in this type of buildings have been linked to an illness termed sick building syndrome (SBS). Sick building syndrome is acknowledged as a state in which building denizens experience serious health or discomfort that appear to be associated to the period used in the building [3]. It is further revealed by Molina, *et al.* [4] that the symptoms cannot be clinically defined or has an identifiable cause. Thus, the imperative of recognizing SBS call for measures to prevent its occurrence in the built environment.

The harmful outcomes of SBS on individual wellbeing and the economic losses to organizations have been documented in various studies. For example, Shoemaker and House [5] inferred a positive relationship between indoor microbial colonization and water damaged buildings on ill health of occupants in US. Vance and Wiessfeld [2] associated SBS occurrences in buildings to water sources and damages resulting to the growth of molds causing bacteria. Additionally, they revealed that insurance companies in US cancel mold coverage and limit to water damage coverage in their policies due to increase in SBS claims. Economic losses in respect to lower staff productivity and performance, increase absenteeism, sick leave application, increased health care costs, loss of building materials and furnishing and legal liability are related challenges of SBS in office buildings [6,7,8,9]. Consequently, these challenges could be overcome in construction projects in Nigeria if the consciousness of SBS is to be integrated into the construction system.

Studies on SBS have taken a broader view in recent time. For instance, Zhang, *et al.* [10] adopted subjective and clinical investigation of human subject blood and serum in establishing dampness and molds association with high prevalence of SBS symptoms in office buildings. Sun *et al.* [11] and Norhidayah *et al*. [12] also utilized survey instrument and field measurement of CO_2 concentration, temperature and relative humidity in determining SBS symptoms in buildings. Sun *et al.* [11] found that female gender reports more SBS symptoms in college dormitory than the male counterparts in China while Norhidayah *et al.* [12] statistically found no association between building types and SBS symptoms in Malaysia. Similarly, Amin, Akasah and Pazzaly [13] objectively measured mean radiant temperature, relative humidity and air velocity with subjective assessment of SBS symptoms in air-conditioned laboratories in Malaysia. Their result revealed that most users of the facility experienced SBS symptoms. Lu, *et al.* [14] studied the relationship between outdoor air pollution, metrological parameters and SBS symptoms in a harmonized questionnaire among adults in China. Statistics multiple regression depicts association of asthma and allergic rhinitis to SBS symptoms. Moreover, Sun, *et al.* [15] investigated the outdoor air pollution in association to SBS symptoms among dwellers in Shanghai district of China. They inferred the incidences of SBS general symptoms of about 79.1% among residents.

Previous studies in Nigeria (6,7,9,16,17,18,19,20) on SBS and indoor air quality have been accomplished in recent time. Their studies concentrated on the incidences of SBS symptoms, indoor air quality and the undesirable impacts to the users in both residential and office buildings. In specific, the study of Okoli and Adedeji [9] examined the prevalence of SBS symptoms in commercial banks buildings within Awka metropolitan of Anambra, South-East Nigeria. Their study revealed that the probed buildings did conceal indoor disorders that can be designated as instigating the signs of SBS to users. The present study investigates SBS symptoms in financial institution buildings and worship centers in a university community. The aim of this article, therefore, is to investigate the environmental physical quantities factors in relation to sick building syndrome symptoms emergence among staff and worshipers in selected public facilities in University of Lagos, Akoka campus. This is significant in that it provides to current literature and knowledge on sick building syndrome in the tropical climate. The study will also contribute to the knowledge and awareness on the average temperature, relative humidity and luminosity indices experienced by staff and users of public buildings in tertiary institutions in Nigeria.

2. REVIEW OF LITERATURE

2.1. Concepts of Sick Building Syndrome

Documentations on sick building syndrome suggest that the symptoms have been recognized worldwide and have gained tremendous attention in medical profession with dedicated sessions at international symposium [21]. Passarelli [22] notes that SBS emerged during the energy ‘crunch’ of 1970s leading to upsurge in energy rates. This situation leads to a shift in architectural dexterities focusing on designs that are envelope tight hence presenting reduced thermal loss and more energy efficient structures. However, the efforts of health care providers in US during the crises helped in discovering of emergent individuals affected by headache and allergic like reaction to unspecified stimuli in sealed buildings [6]. Reactions in form of lethargy, fatigue, headache, dizziness, nausea, irritation of mucous membrane, eye and nasopharyngeal irritation and sensitivity to odors were identified. Thus, sick building syndrome is evident when these indicators of ambiguous and unambiguous complaints are connected together to a certain building.

World Health Organization (WHO) [23] defined SBS as “illness that consists of indications of eye, nose and throat irritation, mental fatigue, headaches, nausea, dizziness and skin irritation that are thought to be connected with time spent in a building”. Al Momani and Ali [7] view SBS as a health condition where people in a building experience symptom of ailment or disorder for no ostensible cause. In the same vein, Okoli and Adedeji [9] describe SBS as “medical cases in which building occupants experience general non-specific symptoms of malaise such as irritation of the eye, nose and throat, lethargy and dizziness”. There is a general consensus among researchers on SBS that the health and comfort challenges experienced by occupants wane shortly later they exit the building with no exact ailment or source that can be labelled [7,24,9].

2.2. Contributing Causes to Sick Building Syndrome (SBS)

A number of research studies have identified similar causes of sick building syndrome (SBS) in various climes. Such nations include Luxemburg [4]; USA [25]; Denmark [26] Jordan [7]; UK [24, 25]; Australia [27] and Nigeria (6,9,17,19,20). Molina *et al.* [4] considered in their report four major contributing causes of sick building syndrome. They are physical: temperature, relative humidity, ventilation, artificial light, noise and vibration; chemical: environmental tobacco smoke, formaldehyde, volatile organic compounds (VOCs), biocides and other gaseous substances like carbon dioxide (CO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3) and sulphur dioxide (SO_2) and odor; biological factors such as growth of microorganism and psychological factors. The origin of sick building syndrome is as an upshot of the factors identified in this present study.

2.3. Environmental Physical Quantities

The physical environmental factors are discussed below.

2.3.1. Ventilation

The system of sealing building tight with air conditioning systems and inoperable windows creates difficulties if the ventilation and air conditioning systems are in anyway unsatisfactory. Iyagba [6] opines that ventilation system is frequently regarded as the greatest aspect affecting buildings which are airtight and having active ventilation system. Ventilation is required in other to remove deteriorated or stale air and replacing it with fresh air thereby creating sort of movement or flow so that occupant obtain a feeling of freshness. Low ventilation rates of less than 10 litres/second/person within air-conditioned buildings are likely to be associated with increased symptoms of SBS [25]. Similarly, Redlich, Sparer and Cullen [29] recommend the provision of 20cubic feet per min ($0.57m^3$/min) of outside air per occupant. Wargocki *et al.* [27] found that increasing ventilation rate in a space decrease the percentage of occupant's dissatisfaction with air quality, intensity of odor and increased freshness of air respectively. They further revealed that optimal ventilation rate minimises the feeling of dryness of mouth and throat in as well as ease in thinking.

2.3.2. Temperature

People react to an environment that is either too cold or too hot. Passarelli [22] reports that occupants' reaction to an environment will be able to have major effects on those who may be vulnerable to excessive temperature. Temperatures between 20^oC and 25^oC have been considered as standard for maintaining a satisfactory level of comfort and occupational activity considering the clothing and the relative humidity [4]. This report related reduction in mental work capacity to temperature above 24^oC and inferred a substantial statistical association between room temperatures beyond 22^oC to the occurrence of SBS symptoms. Conversely, temperature greater than 25^oC can cause headache and temperatures lower than 18^oC can cause colds and influenza [28]. Thus, temperature should be kept in the lower range of the comfort zone.

2.3.3. Relative Humidity

Relative humidity is expressed as air percent or a ratio between the actual amount of moisture in a given volume of air and the amount of moisture that would be necessary to saturate the air. Relative humidity between 30-70% has been established as a range of comfort by people [4]. However, Molina *et al.* [4] report argues that there is no harmony on what institutes the perfect choice of relative humidity. The report views that high standards of 70% in connection with high temperature will be termed uncomfortable and a treat to human health. Passarelli [22] infers that coughing, sore throat and dehydration are negative effects linked to dry, airless situation found in sealed buildings. Generally, it is of researchers views that when the air is too dry, moisture evaporates more easily from the skin and this produces a feeling of chillness even if the temperature is satisfactory. Also, dry air also removes moisture from the nose, throat and eyes causing irritation. Conversely, when the air is too damp, moisture cannot readily evaporate from the skin and this causes the body to be over heated resulting in a feeling of drowsiness [4]. High humidity above 70% will lead to the development of surface condensation, mold growth and structural damages in buildings especially in cold climates.

2.3.4. Lighting

Iyagba [6] considered inadequate illumination, discomfort glare, flicker from luminaires and tinted windows as the possible hitches in the visual environment. Also, in Passarelli [22] identified flicking daylight and mechanical lighting, too bright/dull type of light as issues of concern in emitting the right type of light in working environment. Molina *et al.* [4] found that employing a solid high frequency ballast occasioning in illumination with a decreased variability decreased the occurrence of eye strain and headache by more than 50% in workers. The report further suggests deficient contrast, excessive brightness and glare contribute the advancement of eye irritation and headache in visual stress.

2.3.5. Noise

Noise according to Molina *et al.* [4] "is expressed as the equivalent sound pressure". A weighted level may be a boundary causing tiredness in levels of 70-80 decibels. Infrasound which is defined as sound waves in 0.1-20 Hertz range could initiate dizziness and nausea, nevertheless this is not found in levels below 120 decibels. It is more likely that low frequency noise (20-100 Hertz) which is found in buildings with industrial machines or ventilation machinery may cause problems. Also noise is not regarded as a primary cause of SBS in buildings. However, it is agreed that office workers' productivity and comfort levels can be affected by weak acoustic environment [4].

3. RESEARCH METHODOLOGY

This section summarizes the procedures adopted in realizing the individual objectives of this paper. To achieve this paper, a combination of desktop literature review, handing out close ended questionnaire and field measurement were used. The literatures assist in recognizing variables used in the research instrument while the field measurement determine the confined physical environmental factors. Cross sectional survey was used so that findings of the results can take a broad view and reliable in respect to pool of data from sizable samples [30]. The survey instrument was superficially corroborated by a senior researcher in construction management.

The population consists of selected staffers of three commercial banks and congregations of two faith-based centers respectively in the University of Lagos, Akoka campus. One hundred respondents were purposively sampled from the population and are therefore dimed suitable to provide valid information. Seventy-six valid questionnaires covering thirty bank staffers and forty-six congregations were considered the sample frame. The survey tool was giving out by hand and contains two sections. Section one pursues to identify the personal characteristics of the respondents and as well as their minimum and maximum stay in the buildings. In section two, the respondents were needed to establish the prevalence of SBS symptoms by answering "Yes", "No" and "Neutral" to the identified SBS symptoms. An improvement over the symptoms experienced in the buildings was also ascertained in this section by confirming to "Yes", "No" and "Neutral" to questions posed.

Empirical measurement of three considered physical quantities: temperature, relative humidity and lighting levels were carried out. Thermoigrometer tool measured temperature and relative humidity in the spaces concurrently while BK Precision Light meter tool was applied in computing the internal space lighting levels correspondingly. The temperature and relative humidity appraisals were taken during the day at 2 hours intervals in the month of September in the selected facilities. Day lighting levels in the internal spaces of worship centers were appraised in the daytime at 3m intervals. The data gathered were inputted into the Statistical Package for Social Sciences (SPSS) IBM 21 for analysis. Frequency, percentage, mean and ranking descriptive statistical tools were employed to depict the data.

4. RESULTS AND DISCUSSION

4.1. Personal Data of Respondents and Duration in Buildings

The study pursues to identify the personal characteristics of respondents and as well as their minimum and maximum stay in the buildings. This is depicted in Figure 1. The investigation shows that 56.6% are male while 43.4.4% are female. In terms of age, 27.6% are in the age range of 18-25, 51.3% are within the age of 26-39 while 21.1% are above 30 years of age. The profile of the respondents depicts 21.1% stay between 0-2 hours in the buildings, 23.7% stay between 2-4 hours, 13.3% stay between 4-6hours while 42% of the respondents stayed between 6-8 hours in the buildings. These results imply that the respondents have the minimum requirements in undertaking the survey hence information on SBS symptoms acquired from them will be consistent.

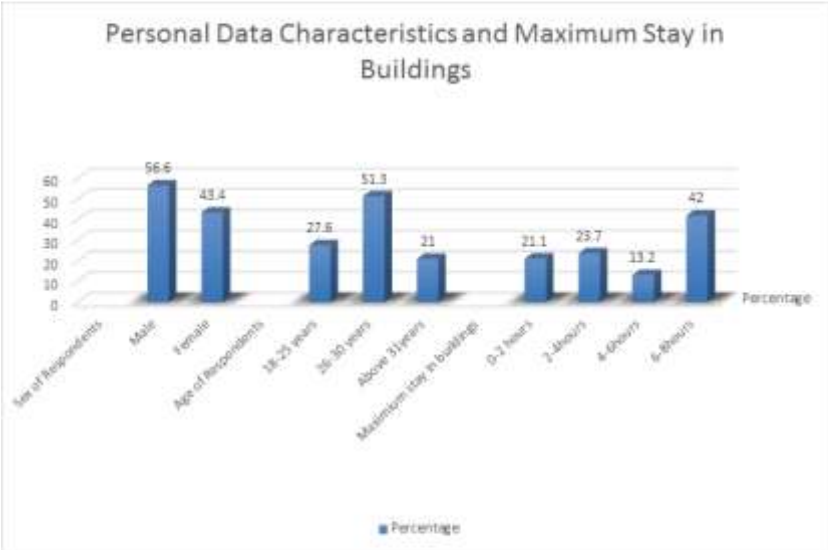

Figure 1 Summary of personal data of respondent’s duration of stay in buildings

4.2. Symptoms Associated with Sick Building Syndrome

The study took to establish the pervasiveness of SBS symptoms amid study respondents. The result in Table 1 shows the percentage contributions to each SBS symptom as presented. Sensitivity to odors ranked first with “Yes” (57.7%), “No” (80.8%), “Neutral” (14.1%), sneezing ranked second with “Yes” (56.4%), “No” (28.2%), “Neutral” (15.4%), coughing ranked third with “Yes” (53.8%), “No” (35.9%), “Neutral” (10.3%), tiredness ranked fourth with “Yes” (52.6%), “No” (35.9%), “Neutral” (7.7%), headache ranked fifth with “Yes” (47.4%), “No” (48.7%), “Neutral” (3.8%), dizziness ranked sixth with “Yes” (38.5%), “No” (52.6%), “Neutral” (9.0%), difficulty in breathing ranked seventh with “Yes” (36.5%), “No” (55.5%), “Neutral” (8.0%), blocked/stuffy nose ranked eighth with “Yes” (34.6%), “No” (57.7%), “Neutral” (7.7%), water eyes ranked ninth with “Yes” (30.8%), “No” (61.5%), “Neutral” (7.7%), running nose ranked tenth with “Yes” (26.9%), “No” (65.4%), “Neutral” (7.7%), “Yes” (34.6%), “No” (57.7%), “Neutral” (7.7%),dry throat ranked eleventh with “Yes” (26.9%), “No” (60.3%), “Neutral” (12.8%), poor concentration ranked twelfth with “Yes” (17.9%), “No” (71.8%), “Neutral” (10.3%), tightness of chest ranked thirteen with

"Yes" (12.8%), "No" (78.2%), "Neutral" (9.0%), irritation of the skin ranked fourteenth with "Yes" (11.5%), "No" (80.8%), "Neutral" (7.7%), This result is not surprising that sensitivity to odors reveals the highest symptom of SBS. This can be attributed higher number of people accommodated within the hours of operations.

Table 1 Sick building syndromes symptoms experienced in building

S/N	Symptoms	Yes (%)	No (%)	Neutral (%)	Ranking
1	odors	57.7	80.8	14.1	1
2	Sneezing	56.4	28.2	15.4	2
3	Coughing	53.8	35.9	10.3	3
4	Tiredness	52.6	35.9	7.7	4
5	Headache	47.4	48.7	3.8	5
6	Dizziness	38.5	52.6	9.0	6
7	A sensation of difficulty in breathing	36.5	55.5	8.0	7
8	Blocked or stuffy nose	34.6	57.7	7.7	8
9	Watery eyes	30.8	61.5	7.7	9
10	Running nose	26.9	65.4	7.7	10
11	Dry throat	26.9	60.3	12.8	10
11	Difficulty/poor concentration	17.9	71.8	10.3	12
12	Tightness of the chest	12.8	78.2	9.0	13
13	Dryness and irritation of the skin	11.5	80.8	7.7	14

4.3. Improvement Over SBS After Leaving the Building

The result of the analysis presented in Figure 2 reveals three responses to improvement on SBS symptoms after leaving each building. The three responses to improvement were "Yes" with 67.9%, "No" with 14.5% and "Neutral" with 15.8%. The finding indicates the existence of sick building symptoms in the buildings investigated hence corroborates the studies of Okolie and Adedeji [9], Sun *et.al* [11] and Amin *et al*. [13].

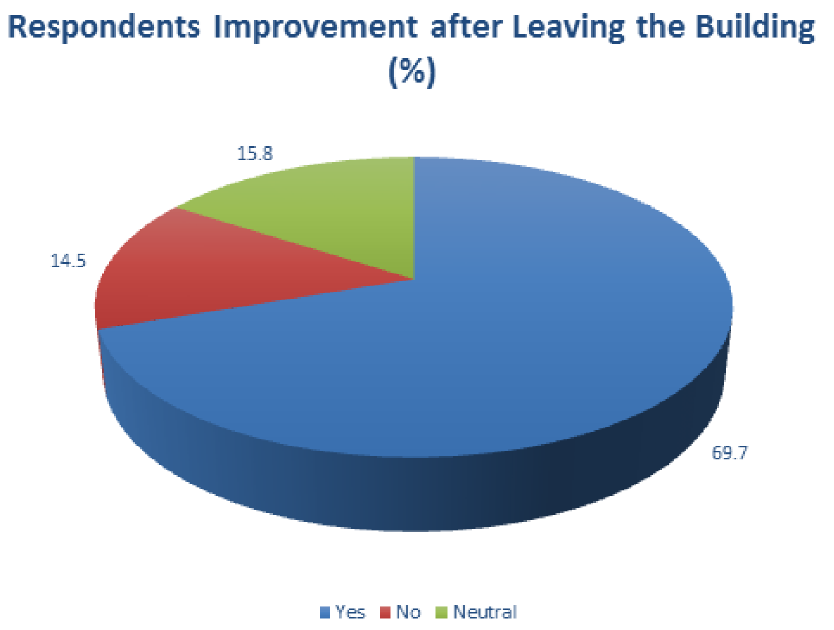

Figure 2 Respondent improvement after leaving the building

4.4. Physical Quantities Dimensions

The physical environmental quantities of lighting level, indoor temperature and relative humidity of the internal spaces were measured with Thermoigrometer instrument and presented in Table 2. Worship center A shows an average lighting level (400 lux), temperature (30.5^{o}C) and relative humidity (50%) respectively. Worship center B shows an average lighting level (464 lux), temperature (29.0^{o}C) and relative humidity (59%) respectively. Bank A shows an average indoor temperature of (27.9^{o}C) and relative humidity (49%) respectively. Bank B shows an average indoor temperature of (28.0^{o}C) and relative humidity (50%) respectively while Bank C shows an average indoor temperature of (25.0^{o}C) and relative humidity (48%) respectively. The results depict temperature above 25.0^{o}C within the studied facilities are not within the optimum thermal comfort level as recommended by Molina *et al.* [4]. The average relative humidity and lighting levels are within the range of 30-70% as recommended by Molina *et al.* [4].

Table 2 Physical quantities measurement

FACILITIES	**PHYSICAL QUANTITIES**		
	Lighting Level (Lux)	Temperature (^{0}C)	Relative Humidity (%)
Worship centre A	1280	30.5	50
	202	30.5	50
	183	30.5	50
	219	30.5	50
	750	30.5	50
	400	30.5	50
Mean	400	30.5	50
Worship centre B	295	30	60
	370	29	58
	295	29.5	59
	272	29.5	54
	530	28.5	58
	565	28	60
	274	39	59
	311	30	58
	910	30	60
	813	29.5	59
Mean	464 lux	29^{0}C	59%
Bank A		29	50
		28.5	49
		28	49.5
		28.5	49
		28	50
Mean		27^{0}C	49%
Bank B		30	49
		29	50
		29.5	57
		30	50
		28	50
Mean		28^{0}C	50%
Bank C		28	48
		28.5	49
		29	48.5
		28	48
Mean		25^{0}C	48%

5. CONCLUSION

This article has reported a study that investigated the environmental physical quantities factors in relation to emergence SBS symptoms among staff and worshipers in selected public facilities in University of Lagos. The study adopted cross-sectional research design. Mixed research methods of questionnaire survey and field measurement were used as the prime instruments for eliciting data from respondents and the selected buildings. Overall samples of one hundred (100) respondents were purposively selected while three (3) commercial banks and two (2) worship centers buildings were objectively investigated for environmental physical quantities. The results signposted that room temperature (>25^{o}C) within the spaces examined was the dominant factor contributed to the SBS symptoms that were experienced by the facilities users. To ensure continued productivity and concentration among staff of banks and worshippers, there is need for rethinking on thermal comfort level required for optimum performance. Rethinking for improving users comfort entails furthering the maintenance of comfortable temperatures to minimum standard. The implication of this paper to physical planning and works department of tertiary institutions and facilities management arm of financial institutions in Nigeria is in designing and maintaining air-conditioning facilities to give the maximum value to users.

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